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Large-Scale Implementation E5 To Support National Energy Self-Sufficiency

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Abstract

This study assesses the feasibility of large-scale E5 gasoline implementation in Indonesia by integrating molasses availability, fuel-grade ethanol capacity, market access, pricing, and projected E100 demand. A descriptive quantitative design was combined with regulatory and supply-chain analyses using official statistics, ministerial regulations, company information, 2020-2024 molasses trade data, bioethanol Market Index Prices from April to July 2026, 182 Pertamax Green 95 retail locations, and regional gasoline demand estimates. Material-balance calculations, percentage analysis, scenario modelling, and spatial interpretation were applied. Indonesia produced 1.636 million tonnes of molasses in 2024, while net exports reached 444,762 tonnes (27.18%), indicating intense competition between energy and non-energy uses. Verified fuel-grade ethanol capacity of 63 million litres per year could supply only 1.26 million kL of E5, equivalent to 6.41% of the projected E5 requirement for Java. Converting 50% of non-fuel ethanol capacity at a 97% dehydration efficiency increased potential E100 supply to 209.54 million litres per year, but covered only 21.33% of Java's demand. The July 2026 bioethanol Market Index Price reached IDR 10,933 per litre, confirming substantial exposure to molasses prices and exchange-rate movements. Large-scale E5 implementation therefore requires verified feedstock balances, quality-based molasses contracts, adaptive regional pricing, selective dehydration retrofits, cluster-based distribution, and bankable medium-term offtake agreements.

Keywords: E5 gasoline; bioethanol; fuel-grade ethanol; molasses; supply-demand gap; offtake agreement; energy security

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INTRODUCTION

Energy self-sufficiency is determined not only by the adequacy of supply, but also by the state's capacity to control feedstock sources, technology, quality, logistics, prices, and end markets. Within this framework, bioethanol has strategic value because it can reduce the use of fossil gasoline components while strengthening the sugarcane agro-industry, increasing the value added of molasses, and expanding the domestic renewable-energy base. This position is consistent with the national downstreaming and economic self-reliance agenda; however, its benefits can be realised only when bioethanol can be produced, contracted, blended, and distributed consistently.

The direction of bioethanol policy has evolved from a biofuel mandate towards implementation instruments. Ministerial Regulation of Energy and Mineral Resources No. 32 of 2008 and Ministerial Regulation No. 12 of 2015 established the basis for biofuel use. Ministerial Decree of Energy and Mineral Resources No. 6034 K/12/MEM/2016 established the bioethanol Market Index Price (Harga Indeks Pasar, HIP) based on the molasses price, a conversion factor, and conversion costs. Decree of the Director General of Oil and Gas No. 252.K/HK.02/DJM/2023 subsequently established the standard for RON 95 gasoline containing 5% bioethanol, while Presidential Regulation No. 40 of 2023 linked the acceleration of sugar self-sufficiency with bioethanol supply. Ministerial Regulation of Energy and Mineral Resources No. 4 of 2025 and Ministerial Decree No. 113.K/EK.05/MEM.E/2026 further strengthened governance and the phased implementation of biofuel use.

A comprehensive regulatory framework has not automatically resulted in large-scale implementation. First, molasses production is not a measure of energy-ready supply because the commodity already serves export markets and domestic demand for monosodium glutamate (MSG), alcohol, yeast, animal feed, citric acid, pharmaceuticals, food products, and chemical industries. Second, ethanol blended into gasoline must meet fuel-grade ethanol or E100 specifications, including a very low water content. Food-grade and industrial-grade ethanol capacity cannot be counted directly as fuel supply without dehydration, quality certification, and the partial reallocation of existing markets. Third, capacity expansion will not be bankable without offtake contracts that secure volume, quality, pricing formulas, delivery points, and risk allocation.

The literature shows that bioethanol blending targets in developing countries cannot be achieved through mandates alone. Feedstock suitability, production capacity, infrastructure, institutions, and market certainty are the principal determinants of supply-chain success (Khatiwada & Silveira, 2017; Nandi et al., 2023). At the process level, yield is influenced by

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feedstock quality, yeast strains, fermentation conditions, distillation, and dehydration (Hawaz et al., 2022; Tse et al., 2021). Accordingly, the feasibility of E5 must be assessed as an integrated system extending from sugar mills and feedstock suppliers to blending terminals and fuel stations.

This study aims to evaluate the extent to which Indonesia's bioethanol capacity and supply chain can support large-scale E5 implementation. The analysis focuses on five operational questions: (1) whether molasses is available on a bankable basis after accounting for trade and competition among uses; (2) how much fuel-grade ethanol capacity is genuinely available; (3) the potential for converting non-fuel ethanol capacity; (4) how prices and market access affect economic viability; and (5) which governance and offtake arrangements are the most realistic for strengthening national energy security.

RESEARCH METHODS

This study employed a descriptive quantitative design based on document review and policy analysis. The design was selected because the study did not test experimental causal relationships; instead, it measured the alignment among feedstocks, industrial capacity, prices, retail networks, and E100 requirements within a single implementation framework. The units of analysis comprised bioethanol policy, molasses production and trade, ethanol-industry capacity, HIP developments, non-subsidised fuel prices, the Pertamax Green 95 network, and regional gasoline demand.

Data sources included Presidential Regulation No. 40 of 2023; Ministerial Regulation of Energy and Mineral Resources No. 4 of 2025; Ministerial Decrees of Energy and Mineral Resources No. 6034 K/12/MEM/2016 and No. 113.K/EK.05/MEM.E/2026; Decree of the Director General of Oil and Gas No. 252.K/HK.02/DJM/2023; Oil and Gas Statistics for the First Semester of 2024; the 2025 Sugarcane Estate Commodity Outlook; Estate Crop Statistics, Volume 1, 2024-2026; Land Transportation Statistics 2024; information from Pertamina Patra Niaga; and information from ethanol companies. Academic literature was used to assess the technical and institutional consistency of the analysis.

Data were collected using a document-extraction matrix containing the year, source, variable definition, unit, region, and verification status. The analysis comprised: (1) mapping the regulatory chronology; (2) constructing a molasses balance that distinguished gross exports, imports, and net exports; (3) calculating fuel-grade capacity and non-fuel ethanol conversion scenarios; (4) comparing the HIP, retail prices, and fuel-station coverage; and (5) calculating E100 demand for an E5 scenario in Java. The principal formulas were: E100 demand = 5% x E5 volume;

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potential E5 = E100 volume/5%; and additional fuel-grade ethanol = proportion of non-fuel capacity converted x dehydration efficiency.

Validation was conducted through cross-document triangulation and unit reconciliation. Molasses production was compared with trade data; total capacity was reconciled with ethanol quality categories; the HIP was linked to the official formula; and E100 demand was recalculated from gasoline volumes. A capacity of 63 million litres per year was used as the conservative baseline because it could be disaggregated by producer, whereas indications of higher aggregate capacity were excluded from the main calculations until utilisation and product quality could be verified.

RESULTS AND DISCUSSION

Policy Development and Implementation Gaps

Indonesia's bioethanol policy has progressed through four stages. The first stage established the biofuel mandate; the second introduced a pricing instrument; the third established the E5 product standard; and the fourth integrated bioethanol with sugar self-sufficiency and phased utilisation. This development indicates that the main problem is no longer the absence of policy legitimacy, but the capacity to translate the mandate into E100 volumes that are produced and absorbed.

The pricing instrument established through Ministerial Decree of Energy and Mineral Resources No. 6034 K/12/MEM/2016 recognises that bioethanol costs are affected by molasses prices and exchange rates. However, the national formula does not fully capture regional logistics costs, dehydration costs, or the risk structures of individual producers. Meanwhile, the E5 standard under Decree of the Director General of Oil and Gas No. 252.K/HK.02/DJM/2023 clarifies that the marketed product is RON 95 gasoline containing 5% E100. Consequently, capacity policy must distinguish anhydrous fuel ethanol from food-grade and industrial-grade ethanol.

Presidential Regulation No. 40 of 2023 strengthens sugarcane-sugar-bioethanol integration; however, programme integration is not equivalent to contractual integration. Targets for sugarcane productivity, sugar-mill capacity, and bioethanol production must be connected through feedstock balances, molasses quality standards, dehydration investment, terminal readiness, and purchase commitments. Without these mechanisms, upstream and downstream targets proceed in parallel rather than as a single value chain.

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Table 1. Development of bioethanol policy instruments and their implementation implications

Period	Instrument	Primary function	Implementation gap
2008-2015	MEMR Regulations 32/2008 and 12/2015	Biofuel utilisation mandate	Does not yet guarantee markets, prices, or supply
2016	MEMR Decree 6034 K/12/MEM/2016	Bioethanol HIP formula	Sensitive to molasses prices and exchange rates; not yet regionalised
2023	Director General of Oil and Gas Decree 252.K/HK.02/DJM/2023	RON 95 E5 gasoline standard	Requires anhydrous E100, quality testing, and blending
2023	Presidential Regulation 40/2023	Integration of sugar self-sufficiency and bioethanol	Requires coordination across upstream supply, industry, and offtake
2025-2026	MEMR Regulation 4/2025; MEMR Decree 113/2026	Governance and phased utilisation	Requires indicators for volume, quality, utilisation, and access

Source: Authors' analysis of the legislation examined

Molasses Balance and Competition among Uses

Molasses is the most critical upstream node for sugarcane-based bioethanol. Technically, its fermentable sugar content can be converted into ethanol. Economically, molasses is not a valueless waste product, but a commodity with established export markets and strong domestic demand. National production must therefore be distinguished from the volume that can actually be contracted for energy use. Bankable availability is determined by quality, location, delivery timing, stocks, price, and sales commitments, rather than production tonnage alone.

Molasses production increased from 1.471 million tonnes in 2020 to 1.686 million tonnes in 2023, before declining to 1.636 million tonnes in 2024. The molasses-to-sugarcane ratio ranged from 4.48% to 4.95%, indicating that volume changes were driven primarily by the amount of sugarcane milled and sugar-mill performance. Trade, however, reduced the space available for domestic supply. Net exports reached 763,169 tonnes in 2023, equivalent to 45.27% of production, before declining to 444,762 tonnes or 27.18% in 2024. The decline in net exports increased indicative domestic availability, but did not mean that the entire volume could be redirected to bioethanol.

In 2023, gross exports of 820,635 tonnes were equivalent to 48.68% of molasses

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production. This figure is important because it reflects direct allocation to overseas markets. In 2024, the gross export share fell to 30.27%. This sharp change demonstrates that molasses is responsive to prices and market demand. The E5 programme therefore faces a crowding-out risk: when export prices or non-energy industrial demand increase, the supply available for bioethanol may contract even when national production remains relatively stable.

The appropriate policy response is not an automatic export ban. A ban imposed without a verified balance could reduce sugar-mill revenues and transfer the burden of the energy programme to the sugar sector. The government should establish a molasses balance for each sugar mill, covering production, stocks, quality, internal requirements, domestic contracts, and exports. A domestic market obligation should be used flexibly only when a supply deficit has been verified and domestic prices provide fair compensation. Quality-based contracts are more important than tonnage-based contracts because Brix, reducing-sugar content, water content, ash, viscosity, and contaminants affect yields and production costs.

Table 2. Indonesian molasses production and trade, 2020-2024

Year	Production (tonnes)	Exports (tonnes)	Imports (tonnes)	Net exports (tonnes)	Net exports/production (%)
2020	1,471,030	430,704	80,707	349,997	23.79
2021	1,510,682	571,615	85,851	485,764	32.16
2022	1,621,543	605,192	79,805	525,387	32.40
2023	1,685,850	820,635	57,466	763,169	45.27
2024	1,636,127	495,251	50,489	444,762	27.18

Source: Rachman (2025), Statistics Indonesia, and the 2025 Sugarcane Outlook; processed by the authors

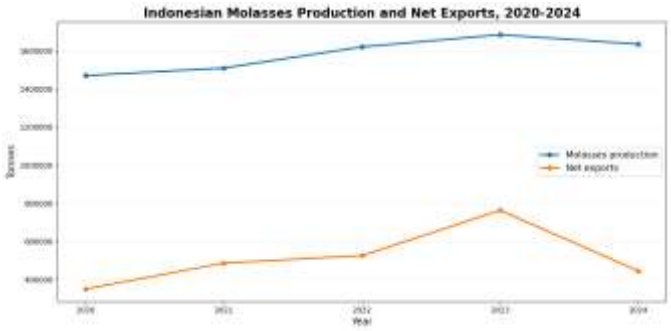


Figure 1. Indonesian molasses production and net exports, 2020-2024
Source: Authors' calculations based on molasses production and trade data

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Fuel-Grade Ethanol Capacity and Conversion Scenarios

The total bioethanol capacity identified in this study was 365.15 million litres per year. Only 63 million litres, or 17.25%, could be specifically identified as fuel-grade ethanol, whereas 302.15 million litres, or 82.75%, comprised food-grade and industrial-grade capacity. This structure confirms that the E5 challenge is not a general shortage of ethanol, but a shortage of anhydrous ethanol that meets fuel specifications.

Fuel-grade capacity is concentrated among a small number of producers and regions. PT Energi Agro Nusantara in East Java, which uses molasses, has a capacity of approximately 30 million litres per year; PT Molindo Raya Industrial has an ethanol-industry base in East Java with recorded fuel-grade potential of approximately 10 million litres; and PT Indonesia Ethanol Industri in Lampung, which uses maize, has a capacity of approximately 20 million litres. This concentration creates East Java and Lampung clusters, but also generates spatial risks because major demand centres and retail facilities are distributed along other corridors.

Food-grade or industrial-grade ethanol can be converted into fuel grade when the initial product quality meets the required standards and dehydration units are available. Conventional distillation generally stops at a concentration of approximately 95-96%, whereas E100 requires an anhydrous purity of approximately 99.5% or compliance with the applicable standard. The most relevant retrofit technologies are molecular sieves or pressure swing adsorption, accompanied by dedicated tanks, water-content control, denaturing, laboratory facilities, and quality certification. Such investment is less capital-intensive than constructing a new plant, but it still requires certainty of supply and offtake.

The conversion scenarios used 302.15 million litres of non-fuel capacity and a dehydration efficiency of 97%. With no conversion, 63 million litres of E100 would produce 1.26 million kL of E5. Converting 50% of non-fuel capacity would generate an additional 146.54 million litres of E100, raising the total to 209.54 million litres and the potential E5 volume to 4.19 million kL. A theoretical 100% conversion would produce 356.09 million litres of E100 or 7.12 million kL of E5; however, this scenario is not a viable policy option because it would eliminate supplies for food, pharmaceuticals, cosmetics, solvents, disinfectants, and chemical industries.

Installed capacity is also not equivalent to actual supply. Actual production is affected by utilisation, downtime, yields, the continuity of molasses or maize supply, product quality, and the offtaker's capacity to absorb volumes. The most rational strategy is therefore to optimise existing fuel-grade capacity, selectively retrofit facilities that are technically and commercially ready, and add new capacity only after contractual and infrastructure performance has been demonstrated.

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Table 3. Capacity balance and non-fuel ethanol conversion scenarios

Scenario	Conversion share	Total FGE (million litres/year)	Potential E5 (kL/year)	Implication
Existing	0%	63.00	1,260,000	Verified baseline
Moderate conversion	50%	209.54	4,190,855	Retains 151.08 million litres for non-energy markets
Theoretical conversion	100%	356.09	7,121,710	Not viable as a target because it eliminates non-energy supply

Source: Authors' calculations; dehydration efficiency of 97%

Prices, Market Access, and the E100 Supply Gap

The economics of E5 must be assessed through the relationship among the bioethanol HIP, retail prices, blending costs, and consumer purchasing power. In July 2026, Pertamax Green 95 was sold at IDR 17,000 per litre in Java, compared with IDR 16,250 for Pertamax RON 92 and IDR 19,300 for Pertamax Turbo RON 98. The IDR 750 difference from Pertamax cannot be treated directly as the cost of bioethanol because the products differ in RON, base gasoline, taxes, blending, storage, quality testing, and commercial policy.

The bioethanol HIP increased from IDR 7,957 per litre in April 2026 to IDR 10,933 in July 2026. The rise of IDR 2,976 per litre, or 37.40%, within three months demonstrates high sensitivity to molasses prices and exchange rates. At the July HIP, the nominal E100 component in one litre of E5 was approximately IDR 546.65. Logistics, losses, blending, storage, water-content control, and quality-assurance costs must still be added. A non-adaptive pricing formula risks squeezing producers when feedstock costs rise or burdening offtakers and consumers when costs decline.

Market access also remains uneven. A compilation as of 10 July 2026 identified 182 Pertamax Green 95 fuel stations, all located in Java. West Java contained 50 locations, East Java 47, DKI Jakarta 38, Banten 27, Central Java 14, and the Special Region of Yogyakarta 6. In total, 89.01% of the locations were concentrated in West Java, East Java, DKI Jakarta, and Banten. This pattern indicates that the product has entered a targeted commercialisation stage, but has not yet become a uniformly implemented E5 mandate.

The concentration of the network is understandable as an initial strategy because urban

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areas have greater demand for non-subsidised fuel, higher mobility, and more developed infrastructure. Nevertheless, the number of fuel stations is not a sufficient indicator of success. Evaluation must measure the volume of E100 absorbed, sales per station, stock-out frequency, logistics costs, and distance from blending terminals. Expanding the number of locations without stable supply and demand merely increases fixed costs and quality risks.

The supply gap is clearly visible in the Java scenario. Gasoline demand reaches 53,838 kL per day, or 19.65 million kL per year. If the entire volume were converted to E5, E100 demand would reach 2,691.9 kL per day, or 982.54 million litres per year. Existing fuel-grade capacity of 63 million litres would meet only 6.41% of this requirement. The 50% conversion scenario would increase supply adequacy to 21.33%. Even the theoretical 100% conversion scenario would meet only approximately 36.24%. Full E5 expansion in Java therefore requires investment in new capacity, rather than merely reallocating existing ethanol.

At the July 2026 HIP, the value of E100 procurement required to meet the entire Java scenario would reach approximately IDR 10.74 trillion per year before transport, blending, storage, testing, and distribution costs. This scale demonstrates the need for phased implementation. The programme can begin in clusters with the most readily available E100 supply, terminals, and fuel-station networks, and then expand after utilisation, quality, and demand have been demonstrated.

Table 4. Fuel prices and the bioethanol HIP, April-July 2026

Category	Product	Period	Price (IDR/litre)	Description
Fuel retail price	Pertalite RON 90	July 2026	10,000	Government-assigned fuel
Fuel retail price	Pertamax RON 92	July 2026	16,250	Non-subsidised
Fuel retail price	Pertamax Green 95 (E5)	July 2026	17,000	Non-subsidised fuel containing 5% bioethanol
Fuel retail price	Pertamax Turbo RON 98	July 2026	19,300	High-octane non-subsidised fuel
Bioethanol HIP	Bioethanol	April 2026	7,957	Procurement benchmark

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Category	Product	Period	Price (IDR/litre)	Description
Bioethanol HIP	Bioethanol	May 2026	7,992	Increased by 0.44%
Bioethanol HIP	Bioethanol	June 2026	8,062	Increased by 0.88%
Bioethanol HIP	Bioethanol	July 2026	10,933	Increased by 35.61% from June

Source: Pertamina Patra Niaga and the Directorate General of New, Renewable Energy and Energy Conservation (2026); processed by the authors

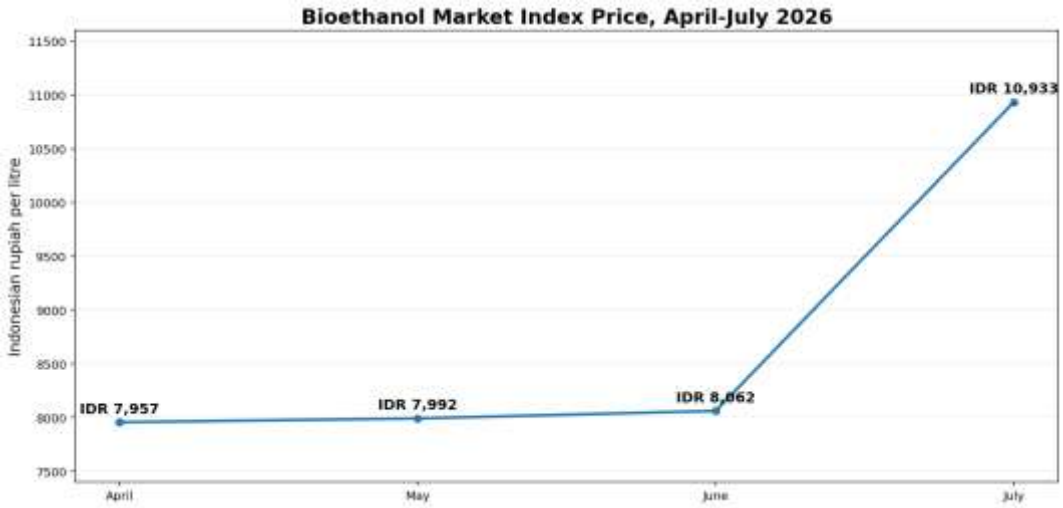


Figure 2. Bioethanol Market Index Price, April-July 2026

Source: Directorate General of New, Renewable Energy and Energy Conservation (2026); processed by the authors

Table 5. Distribution of Pertamax Green 95 fuel stations in Java as of 10 July 2026

No.	Province	Number of fuel stations	Percentage (%)
1	West Java	50	27.47
2	East Java	47	25.82
3	DKI Jakarta	38	20.88
4	Banten	27	14.84

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No.	Province	Number of fuel stations	Percentage (%)
5	Central Java	14	7.69
6	Special Region of Yogyakarta	6	3.30
	Total	182	100.00

Source: Authors' compilation of Pertamax Green 95 locations as of 10 July 2026.

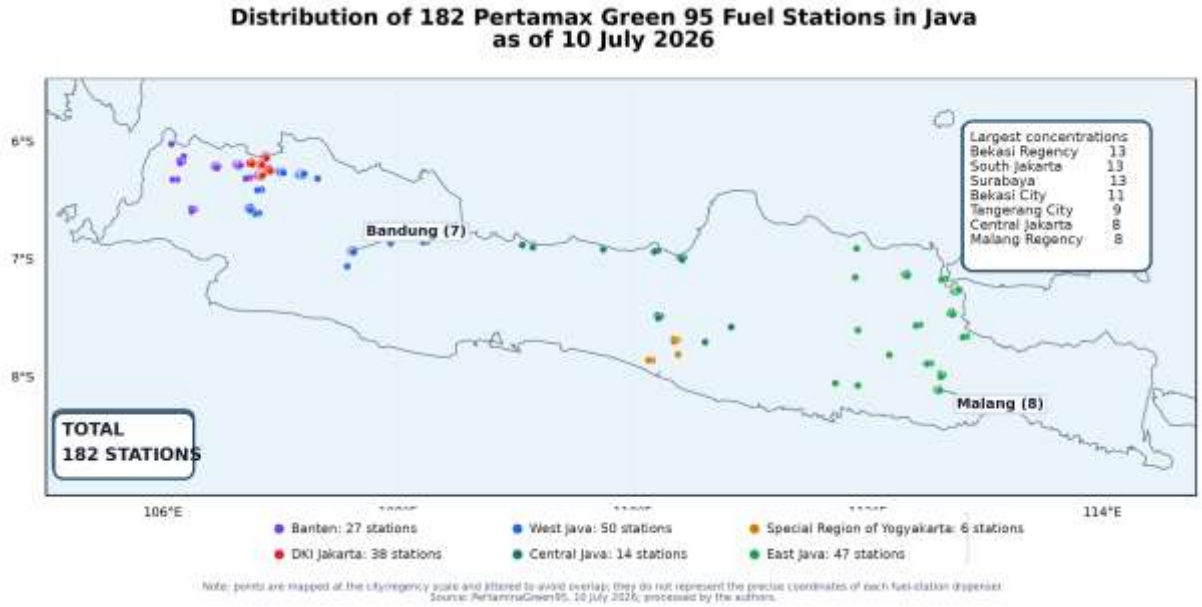


Figure 4. Distribution map of 182 Pertamax Green 95 fuel stations in Java as of 10 July 2026
Source: PertaminaGreen95, post dated 10 July 2026; processed by the authors

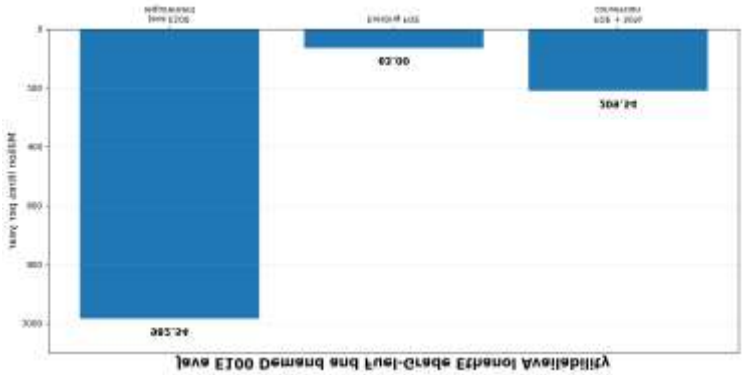


Figure 3. Java E100 demand compared with fuel-grade ethanol availability
Source: Authors' calculations based on gasoline demand and capacity scenarios

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Table 6. Adequacy of E100 supply under the Java E5 scenario

Scenario	E5 potential/requirement	E100 volume	Adequacy (%)
Java E5 requirement	19,650,870 kL E5/year	982.54 million litres E100/year	100.00
Existing national FGE	1,260,000 kL E5/year	63.00 million litres E100/year	6.41
FGE after 50% conversion	4,190,855 kL E5/year	209.54 million litres E100/year	21.33
FGE after 100% conversion (theoretical)	7,121,710 kL E5/year	356.09 million litres E100/year	36.24

Source: Authors' calculations based on an E5 blend and 97% dehydration efficiency

Governance Strategy and Offtake Design

The upstream, industrial, pricing, and market findings indicate that the principal E5 bottleneck is a coordination failure across the value-chain links. Molasses production is not yet tied to producer requirements; non-fuel ethanol capacity is not connected to dehydration investment; fuel-grade producers lack certainty regarding medium-term absorption volumes; and the fuel-station network is not always developed according to proximity to supply and terminal readiness. Offtake must therefore be positioned as a governance instrument, rather than merely a sales contract.

The first contract links sugar mills or feedstock suppliers with bioethanol producers. It covers volume, quality, location, delivery timing, loss tolerances, pricing formulas, and penalties. The second contract links E100 producers with fuel-distribution business entities. It must specify product standards, base volumes, flexibility bands, delivery points, schedules, quality testing, rejection mechanisms, and a conditional minimum absorption obligation. The third contract governs terminals, transport, storage, water protection, losses, and emergency-response procedures. The fourth links stock allocation to fuel-station sales and demand reporting.

An absolute take-or-pay model could burden the offtaker when supply fails to meet quality or scheduling requirements. Conversely, a contract without a minimum volume would place the entire investment risk on the producer. A more proportionate arrangement is a conditional minimum offtake obligation: a base volume must be absorbed when the producer meets specifications and delivery schedules, with a flexibility band to accommodate demand

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changes. The contract term must be long enough to support financing for retrofits and new investments, accompanied by annual performance-based evaluations.

The pricing formula must be adaptive and regional. The HIP can remain the base index, but it should separate feedstock, conversion, dehydration, certification, and logistics components. Regional premiums must be transparent because producers in Sumatra should not be required to use a Java cost structure without adjustment. To mitigate volatility, the government can apply moving averages, periodic review intervals, and renegotiation trigger thresholds. Fiscal support should be provided only for verifiable economic gaps and linked to actual volumes, utilisation, quality, and fossil-gasoline substitution.

Implementation should adopt a cluster approach. The first stage should optimise the existing 63 million litres of capacity in the most prepared regions, particularly East Java and the Greater Jakarta-West Java-Banten corridor. The second stage should selectively retrofit dehydration capacity among producers that have feedstocks, efficiency, terminals, and contracts. The third stage should expand to Central Java, the Special Region of Yogyakarta, and Lampung after supply, quality, cost, and sales indicators have stabilised. Targets should not be limited to the number of fuel stations; the principal indicators must be absorbed E100 volumes, facility utilisation, continuity of supply, and distribution cost per litre.

The government should establish an integrated data system across the Ministry of Energy and Mineral Resources, Ministry of Agriculture, Ministry of Industry, Ministry of Trade, and Ministry of Finance. The system should trace molasses from sugar mills, fermentation and dehydration volumes, quality-test results, terminal deliveries, blending realisation, stocks, and sales. Independent audits are required to prevent information asymmetry and ensure that incentives are paid on the basis of verified outcomes.

From the 4A+1S energy-security perspective, this design improves availability through verified supplies and E100 capacity; accessibility through cluster-based networks; affordability through logistics efficiency and pricing formulas; acceptability through consistent quality and public communication; and sustainability through the protection of non-energy markets, feedstock diversification, and impact evaluation. E5 can therefore serve as an energy-security instrument when its implementation strengthens national control over the value chain, rather than merely adding another premium fuel variant.

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Table 7. Strategic priorities for governing 5% bioethanol implementation

Priority	Time horizon	Key indicator
National molasses balance	0-12 months	Verified mill-level data on volume, stocks, quality, contracts, and exports
Quality standards and traceability	0-18 months	Contracts based on Brix/reducing sugars; sampling methods and reference laboratories
Adaptive regional pricing formula	0-12 months	Transparent HIP; logistics index; review mechanism and trigger thresholds
Medium-term offtake	0-12 months	Conditional minimum volume, quality, schedule, delivery point, and risk allocation
Selective dehydration retrofits	1-3 years	Additional E100 capacity in operation; measured utilisation and investment cost per litre
Cluster roadmap	1-3 years	Terminal readiness, stock continuity, sales per fuel station, and declining distribution costs
Feedstock diversification	2-5 years	Viable alternative supplies without disrupting food systems or the environment
Performance audits and evaluation	Semi-annual/annual	Absorbed volume, quality, fossil-fuel substitution, fiscal costs, and consumer acceptance

Source: Synthesis of the research findings

CONCLUSION

Large-scale E5 implementation in Indonesia is a value-chain governance challenge, rather than merely a question of ethanol availability. Molasses production of 1,636,127 tonnes in 2024 demonstrates a significant feedstock base; however, net exports of 444,762 tonnes, or 27.18%, and non-energy industrial demand limit the volume that can be contracted. Domestic availability is not equivalent to energy supply because quality, location, price, stocks, and sales commitments determine actual feasibility.

Verified fuel-grade ethanol capacity of 63 million litres per year would produce only 1.26 million kL of E5, equivalent to 6.41% of the Java scenario requirement. Converting 50% of non-fuel capacity at 97% efficiency would increase supply to 209.54 million litres of E100 and meet 21.33% of demand. Even converting all non-fuel capacity would meet only 36.24% and would not be viable because it would disrupt the food, pharmaceutical, cosmetics, and chemical

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sectors. The supply gap is therefore structural and requires utilisation optimisation, selective retrofits, and investment in new capacity.

On the pricing side, the increase in the HIP from IDR 7,957 to IDR 10,933 per litre between April and July 2026 confirms vulnerability to molasses prices and exchange rates. In terms of access, the 182 Pertamax Green 95 fuel stations remain concentrated in Java, particularly in four principal provinces. This condition supports cluster-based phasing, but cannot yet be characterised as national implementation. Performance measures must shift from installed capacity and the number of fuel stations to the volumes of E100 that are contracted, quality-approved, absorbed, blended, and sold.

The recommended strategy consists of a sugar-mill-based national molasses balance, quality standardisation and traceability, an adaptive regional pricing formula, bankable medium-term offtake contracts, selective dehydration retrofits, cluster development, feedstock diversification, and performance-based audits. Offtake is the binding mechanism because it provides investment certainty for producers while protecting fuel-distribution business entities through quality and scheduling requirements. Implementation must be phased and expanded only when supply, infrastructure, costs, quality, and demand have demonstrated stability.

This study contributes by integrating feedstock balances, capacity, technology, prices, E100 demand, market access, and contract design within a single implementation framework. Its limitations are that some capacity, utilisation, logistics-cost, and regional demand data remain compilations that require audits at company and terminal levels. Further research should examine E100 production costs by producer, the demand elasticity of Pertamax Green 95, blending-terminal readiness, fiscal impacts, import reductions, and life-cycle emissions.

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